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The Diet and Daily Forage Consumption of an Experimental Herd of Sheep on Utah's Winter Range

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THE DIET AND DAILY FORAGE CONSUMPTION OF AN EXPERIMENTAL HERD OF SHEEP ON UTAH'S WINTER RANGE

by

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INTRODUCTION

The forage produced on Utah's winter range is generally deficient in some nutrients that are required for the phase of sheep production that takes place on these ranges. This forage need only supply little more than maintenance ration, but because of low forage production on these areas and generally low quality forage, these requirements often are not met.

Without adequate nutrients for maintenance, wool production, and the development of the fetus in pregnant ewes, losses occur to the sheep industry of the state. These losses result from reductions in lamb crops and fleece weights, and because sheep are less able to take advantage of the more productive summer ranges if they arrive on these ranges in a low nutritive state.

In the way of correcting nutritional deficiencies that may occur on the winter range, supplemental feeding has been advocated by animal specialists. The practice of supplemental feeding, however, has not been generally accepted by the livestock producers of the state. In general, the reason for this lack of acceptance is, in part, the recommendation of expensive supplements that supply more than is required by the animals. Further, growers often actually obtain little response from feeding supplements to sheep.

Winter range forage generally is recognized to be deficient in phosphorus, and thus the diet of the sheep is lacking in this nutrient. The lack of other nutrients in the diet, although suspected, is not known.

To determine what may be lacking in the diet of the sheep, not only must the type of forage consumed and the quality of this forage

be known, but also the quantity of forage eaten daily must be known. This is especially true where the forage may be suspected of only meeting the minimum requirements of the grazing animal.

Cook et al. (8) have shown that the quality of forage ingested may be considerably higher in nutritive content than indicated by a chemical analysis of the forage before grazing. Recommendations for supplying nutrients in the form of supplements that apparently are lacking in the forage, as determined by a chemical analysis of the entire forage plant, results in a waste of money to the livestock operator.

The purpose of this investigation was to determine which forage plants are eaten, the factors which effect the choice of certain forage plants, the amount of forage consumed daily, and the factors which limit forage consumption. With this type of information, the nutritive state of the animal grazing the winter ranges can be determined and recommendations may be made that are in keeping with sound management practices.

REVIEW OF LITERATURE

It is the opinion of several investigators that a method designed to measure the forage consumption and diet of sheep must necessarily consider the abundance and composition of the forage, habits of the animal, season of year or stage of plant growth, climatic conditions, and management practices (10, 13, 14).

Doran (14) found that the relative amount of feeding time ewes spend grazing grasses, weeds, and browse is closely correlated with the relative abundance of each type of plant. Experimental work by Stapledon and Jones (31) has shown sheep to be highly selective in

their diet, prefering the more succulent leaves to the coarser stems of grasses. Similar results were obtained by Cook, et al. (8). Davies (11) found sheep not only selective in their diet but also discriminating in their choice of the more nutritious forage, However, he thought this to be largely accidental and largely a matter of palatability.

The amount of forage consumed, as well as the type of forage consumed, is dependent upon a number of factors. Stapledon and Jones (31) found that the herbage consumed per day by sheep penned on abundant herbage, varied within considerable limits. It was not determined, however, whether this variation was influenced most by the production of the herbage, the degree of moisture of the herbage, or the botanical and chemical composition of the herbage. It was noted, however, that the herbage consumed per day was higher when it consisted largely of clover stems than when it consisted of clover leaves. Woodman, et al. (34) found that sheep consume a bigger ration in terms of pounds of dry matter when on pasture than when subsisting out of doors on diets composed of hay, swedes, and concentrates. The distinction was most marked with young leafy pasturage. Smuts and Marias (29) found the average daily weight of sheep to increase or decrease with the protein content of the pasture, which changed with the seasons of the year. The decrease or increase in body weight was accompanied by the decrease or increase in forage consumption. However, when forage consumption was expressed in ratio to a unit of body weight, to a unit of the 0.75 power function of body weight, or per square meter of body surface there was essentially no difference in the amount consumed in the various seasons.

Methods for determining forage consumption have been used more in the field of pasture research than in the field of range research. A common procedure used by pasture investigators (16, 17, 23, 31) is to clip the forage from a representative section of the area to be grazed and equate this quantity to the production of the area. Animals are then allowed to graze the area for a definite period of time after which another representative grazed section is clipped to determine the quantity of forage remaining on the area. The difference of the two figures is the amount consumed by the animals. The disadvantages of this procedure have been reviewed by Garrigus and Rusk (20).

Another approach to the problem of determining forage consumption is the dry matter ratio method (20). This procedure involves the collection of the feces voided each day by the grazing animal, and the determination of digestibility of the dry matter consumed in digestion stalls either with the same animals to be used in the grazing trials (20) or with similar animals (34). The forage consumption is then calculated using the percentage digestibility of the dry matter and the dry matter voided each day in the feces.

Gallup, et al. (18) emphasized that digestion coefficients could be calculated and feed intakes determined for animals on pasture if some "tracer" material could be found. Experiments by these investigators with silica as the tracer material proved unsatisfactory because of the inclusion of some soil in the diet. Forbes and Garrigus (16) substituted lignin as the "tracer" material in experiments with six grade-Herefords and fifteen wethers. The results obtained using this procedure were compared with results obtained using the dry matter ratio method (20) and were found to be in close agreement in three trials

out of the four conducted. The lignin ratio method (15) used by Forbes and Garrigus (16) is based on the assumption that lignin, a constituent part of plant material, is not digested by the animal. Forage consumption is then determined by knowing the percentage of lignin in the forage, the quantity of dry matter excreted, and the lignin in the dry matter excreted. The following equation serves to illustrate the method:

$$\text{D.M. consumed (lbs)} = \frac{\text{D.M. excreted (lbs)} \times \text{lignin in D.M. excreted (\%)}}{\text{lignin in D.M. consumed (\%)}}$$

Considerable controversy has arisen over the validity of the assumption that lignin is not digested. Davis et al. (12) reported the lignin in pea vines and lima-bean vines to be 16.2 and 10.6 percent digestible when fed to four yearling and two-year old Hampshire ewes. Kondi and Meyer (2) found lignin was digested comparatively well, 35.1 to 64.0 percent, in grass and legume forage fed to sheep. Other investigators (9, 15, 16) have reported lignin undigestible in trials with steers, wethers, and jack rabbits. Ellis et al. (15) attributes this discrepancy in the reports on the digestibility of lignin to the chemical procedures used to isolate it from the feeds and feces. These investigators found a form of the "72% H_2SO_4" method to be the most satisfactory for such determinations. The reader is referred to articles by Crampton et al. (9) and Ellis et al. (15) for a discussion of the chemical methods used to determine lignin.

It sometimes becomes necessary to know the forage consumption of animals of various weights. Brody et al. (5) from an analysis of a large body of basal (energy) metabolism data of mature animals of different species ranging in weight from 0.02 to 4000 kilograms (mice to elephants) showed that the basal metabolism tends to vary with the

0.73 power of body weight. Kleiber (22) arrived at a similar figure for the basal metabolism of thirteen groups of various animals. Brody (4) later justified the use of the 0.73 power function theory for determining the maintenance of an animal as well as the basal metabolism on the following basis : The largest expense for maintenance energy, approximately 85%, is the basal energy metabolism. The second largest expense for maintenance is the muscular expense, the walking about associated with living, and is directly proportional to body weight. However, reasoning on the basis of dimensional analysis, Brody came to the conclusion that the larger animal makes slower and fewer movements so that the voluntary energy expenditure for muscular exercise tends to parallel the basal metabolism, i.e. it tends to vary with the 0.73 power of the body weight rather than directly with body weight. The arguments in favor as well as against this theory have been reviewed by Brody (4).

The reader is referred to articles by Green (21) and Cook (6) for a review of the methods used to determine the diet of the grazing animal.

METHODS OF PROCEDURE

This study was designed to provide information concerning the species composition of the diet and the amount of forage consumed daily by an experimental herd of sheep grazing a typical range allotment on Utah's winter range area.

Data for the study were collected between November 26, 1947 and April 4, 1948. Forage production, the species composition of the diet, and the amount of forage consumed daily were determined at intervals during the grazing season.

The study area[1] was located in Pine Valley, 40 miles northwest of Milford, Utah. Grazing on this allotment was confined largely to the coves and upper parts of the large alluvial fans that radiate out from these coves along the west face of the Wah Wah mountains.

The principal forage plants were: shadscale (Atriplex confertifolia), black sage (Artemisia nova), yellow-brush (Chrysothamnus stenophyllus), white sage (Eurotia lanata), snakeweed (Gutierrezia sarothrae), Brigham tea (Ephedra nevadensis), three-awn grass (Aristida longiseta), blue grama (Bouteloua gracilis), curly grass (Hilaria jamesii), Indian rice grass (Oryzopsis hymenoides), needle-and-thread grass (Stipa comata), and sand dropseed (Sporobolus cryptandrus).

The climate of this region is characterized by an annual precipitation of 6 or 7 inches occuring principally as spring rains and winter snows, with occasional summer showers that vary greatly in frequency and amount of precipitation from year to year. Subzero temperatures usually occur during some winter nights while the summers are characterized by long periods of drought with maximum midday temperatures above 90 and occassionally above 100 degrees F.

Soils of the region are highly variable. Poor drainage conditions coupled with low precipitation results in concentrations of soil salts at some place in the soil profile. This concentration of salts appears near the surface on the valley bottoms but is at somewhat greater depths on the foothill slopes.

During the time of this study, Nov. 26, 1947 to April 4, 1948,

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1. A portion of the allotment of Wilford Wintch, a private cooperator with the Utah Agricultural Experiment Station, who furnished the sheep used in this study.

the allotment was free of snow until the 4th of December at which time approximately 10 inches fell within 24 hours. From this time until the latter part of March, snow covered parts of the ground and much of the vegetation on the study area. However, open weather for short periods reduced snow depths and exposed areas of snow-free ground periodically throughout the grazing season, particularly on south and west facing slopes.

At the beginning of the study, a random sample of each age group in a typical winter band of grade Rambouillet sheep was taken to form the experimental herd[2]. After the experimental herd had been formed, the winter grazing season was subdivided into 5 grazing periods arbitrarily set as three weeks in length. However, due to climatic and other conditions that existed during the time of the study the periods varied in length from 21 days in period 1 to 25, 20.5, 35.5, and 24 days in periods 2, 3, 4, and 5 respectively.

The band of sheep that normally graze the allotment generally graze the entire area lightly within a month or two after arriving on the desert. The allotment is then systematically regrazed the remainder of the season until all the forage is utilized.

To simulate normal grazing with the experimental herd, areas within grazing periods 1 and 2 were grazed for the first time of the season by the experimental sheep, whereas the areas grazed during the remaining periods had been previously grazed by the band that normally use the allotment.

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2. The experimental herd originally consisted of 214 sheep with an equal number in each age class plus 10 wether lambs. This number was reduced to 160 animals on the 30th of December.

In each grazing period the sheep grazed out from a centrally located campsite during the day and were returned in the evenings to be bedded in a temporary corral constructed of metal posts and snow fencing[3]. (See fig. 1.)

To determine the diet of the grazing animals in each period, the vegetation was sampled before and after grazing during each period. Samples were taken along transects approximately 900 feet in length which were distributed about the centrally located campsite at distances varying from 1/4 to 1 mile from the campsite. The number of transects on which samples were taken ranged from 4 to 6 in the various periods.

The data obtained from each transect were used to determine the forage production before grazing, production after grazing, and by difference the amount consumed for an average 100 square feet of surface area. The values for a 100-square-foot area on each transect were averaged to obtain values that could be applied to the entire area grazed during the period.

The procedure used by Green (21) to determine forage production before grazing and after grazing and the amount consumed on each transect was adopted for use in this study. The only change of this procedure was in the equipment used to determine the percentage of forage cover along the transect. For this purpose a 25-square-foot frame, constructed of light steel tubing (fig. 2), was used to delimit the area of each plot along the transect. A sliding cross-piece, 1 foot wide and 5 feet in length, graduated to read 0.25 percent or

3. The corral and feeding pens were used in connection with a supplemental feeding study carried on at the same time by the Animal Husbandry Department of the College.

Figure 1. Temporary corral and supplemental feeding pens used in the study.

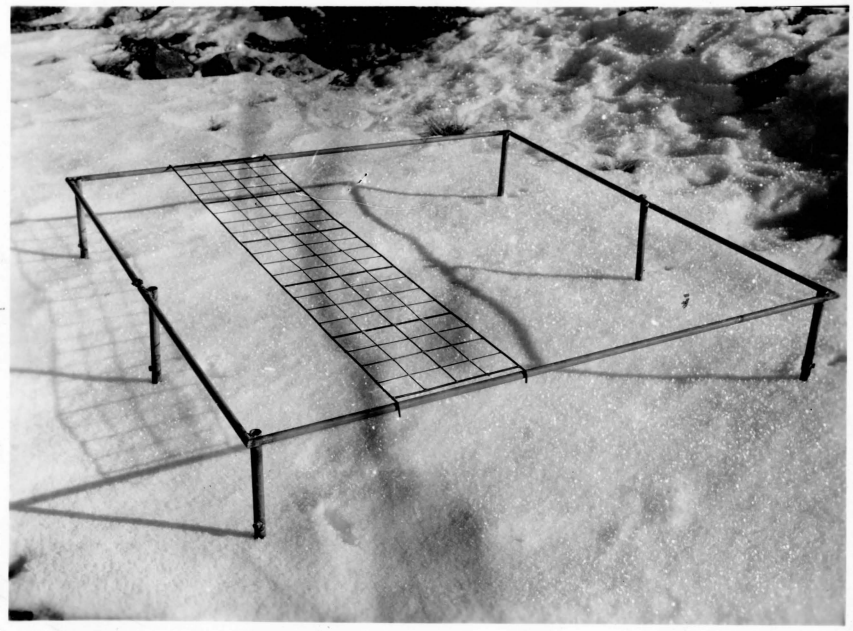

Figure 2. The 25-square-foot frame and the 5-square-foot sliding cross piece used to determine the percentage of ground covered by each species.

1/16th of a square foot, was used to aid in determining the percentage of ground covered by each species within the plot and the number of units per square foot of forage (fig. 3).

Briefly, the procedure consisted of first determining the average percentage of ground covered by each species along the transect, and the average number of units[4] of each species per square foot of forage produced. The percentage of ground covered by each species on the transect represented the average obtained from ten plots taken at equal intervals along the transect. The number of units per square foot of forage for each species was determined by counting all the units of each species in the ten plots and dividing by the total number of square feet of forage of each species in the plots.

After determining the number of units per square foot of forage and the average percentage of ground covered by each species, units of each species were collected in paper bags out and back along the transect both before and after grazing the area by the sheep. Each sample was stored for a period of approximately 2 months after which it was weighed and the average air-dry weight per unit determined. The combined samples of each species before grazing and of each species after grazing that were collected in a single period were ground in a Wiley mill and a 100 gram aliquot taken for determination of oven-dry weight and lignin content. The yield after grazing was subtracted from the yield before grazing to determine the amount consumed. Lignin was determined by the method of Ellis, et al. (15).

The average unit weights (air dry) were multiplied by the average

4. A description of the units and observations used in this study is given in the appendix.

Figure 3. The 5-square-foot cross-piece used to determine the percentage of ground covered by each species. Each small square represents 0.25 percent or 1/16th of a square foot of ground cover.

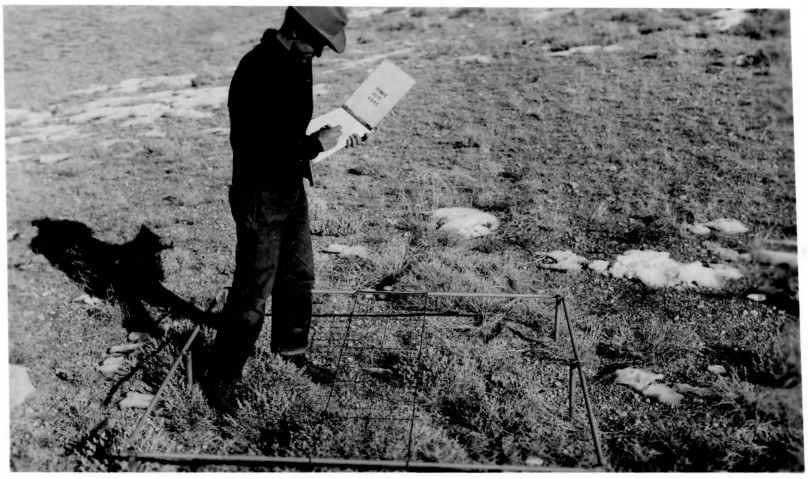

Figure 4. Use of the 25-square-foot-frame to read percentage of ground covered by each species.

number of units per square foot of forage and the percentage of ground covered by each species to determine for a 100-square-foot area the average forage production before grazing, again after grazing and, by difference, the amount consumed. These data were then used to determine the production before and after grazing, and the amount consumed per acre within each period.

The diet in each period was computed from the amount of each species consumed from an average 100-square-foot area within the period.

The difference of the lignin content of the forage before and after grazing, as determined by multiplying the percentage lignin in each sample by the forage production before and after grazing for each plot, gave the grams of lignin consumed per plot. The percentage of lignin in the diet for the period (used in calculation of forage consumption) was computed from the amount of dry matter and lignin consumed per plot.

The forage consumption of wether lambs was determined for each grazing period by the use of lignin ratio method (15) and, by the application of Brody's theory (4) that animals consume forage in proportion to a power function (0.73) of their body weight, consumption of each age class was calculated.

The procedure consisted of collecting feces in each period from wether lambs by means of specially constructed feces bags attached to the animal (fig. 5). The number of animals used for collection purposes varied in each period from 2 in periods 1 and 2, to 4, 3, and 5 in periods 3, 4, and 5. Collections were started 4 days after the beginning of each grazing period and continued until the close of the

Figure 5. Illustration of the harness and feces bag used for the collection of feces in each grazing period.

grazing period. The feces bags were emptied once daily (fig. 6) and the feces were accumulated for the entire period in 5-gallon wide-mouth bottles[5]. At the close of the period, the accumulated feces of each animal were weighed, thoroughly mixed, and a 2 pound aliquot obtained for oven dry matter and lignin content determination. Lignin was determined by the method of Ellis, et al. (15).

Forage consumption of each collection animal was determined from a calculation of the percentage lignin in the forage and in the feces, and the average amount of feces excreted daily (pounds of dry matter).

All sheep in the experimental herd were individually weighed at 28-day intervals (fig. 7) and the average body weight in each age class determined. Using the average weight of the lambs from which feces collections were made and the average amount of forage consumed by these animals, the amount consumed by an average sheep in each age class was calculated on the basis that animals consume forage in proportion to the 0.73 power of the body weight.

RESULTS AND DISCUSSION

COMPOSITION OF THE DIET

Sheep are limited in their choice of forage to that found on the areas they graze. The choice of plants available to sheep grazing the study area was not large and few of these were distributed over the entire area. Reductions in the availability of the forage because of climatic or herding conditions reduced even more the choice of forage available to the animals.

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5. A preservative consisting of 97 parts ethyl alcohol and 3 parts of concentrated hydrochloric acid was used in the bottles to prevent bacterial action on the feces.

Figure 6. Illustration showing the procedure used to empty the feces bags each day.

Figure 7. The procedure used to weigh the sheep at 28 day intervals.

Composition of the Diet by Forage Classes

An interesting relationship existed between the preference shown for browse and grass during the grazing season. The areas grazed in the first two periods were grazed for the first time of the season by the experimental herd, whereas the areas grazed in the remaining periods had been previously grazed by the band of sheep that normally use the allotment. Browse produced more forage available for grazing at the beginning of the season than at any other time and was also the most palatable at this time. Browse was more preferred at this time because of the abundance of fruit and leaves remaining on these species. The leaves and fruit were removed by grazing and shattering due to weathering as the season progressed and the preference decreased accordingly. Although grass produced more forage available for grazing at the beginning of the season (period 1) than on the areas grazed later, it was the least preferred of the two classes at this time. The rank, coarse growth attained by grass during the previous growing season was avoided as much as possible by the sheep at the beginning of the winter. However, with reduction of the rank growth by cattle and sheep previous to grazing by the experimental herd, and the softening of the coarse stems remaining by snow, the preference for this class of forage increased in the latter periods. The decrease in the preference for browse also had a marked effect on increasing the preference shown for the grass as the season progressed.

Data from table 1 show that the relative amount of each forage class in the diet agrees closely with the relative amount produced by each class.

Browse produced 76.9 and 100.0 percent of the available forage

Table 1. Forage production[1], consumption, and composition of diet by species and by grazing periods during winter grazing season

Species	Period 1 11/26/47 to 12/18/47				Period 2 12/18/47 to 1/13/48				Period 3 1/13/48 to 2/3/48				Period 4 2/3/48 to 3/10/48				Period 5 3/10/48 to 3/4/48				Seasonal
	Average forage prod. per acre	Percent of total prod.	Amount consumed per acre	Percent of diet	Average forage prod. per acre	Percent of total prod.	Amount consumed per acre	Percent of diet	Average forage prod. per acre	Percent of total prod.	Amount consumed per acre	Percent of diet	Average forage prod. per acre	Percent of total prod.	Amount consumed per acre	Percent of diet	Average forage prod. per acre	Percent of total prod.	Amount consumed per acre	Percent of diet	Percent of diet
	pounds		pounds		pounds		pounds		pounds		pounds		pounds		pounds		pounds		pounds		
BROWSE																					
Atriplex confertifolia Shadscale	399.2	62.2	149.9	66.5	194.8	77.7	8.1	31.2	246.3	64.2	47.8	56.3	135.8	48.8	18.5	40.8	89.6	34.4	20.4	25.6	53.0
Artemisia nova Black sage					2.3	0.9	1.0	3.8													0.2
Chrysothamnus stenophyllus Yellow-brush	67.5	10.5	36.6	16.2	10.2	4.1	1.5	5.9	4.3	1.1	1.7	2.1	10.9	3.9	2.0	4.5	24.6	9.5	6.6	8.3	10.5
Eurotia lanata White sage	11.6	1.8	3.1	1.4	16.0	6.4	6.6	25.3					16.5	5.9	- 0.4	- 0.9					2.0
Gutierrezia sarothrae Snakeweed	15.1	2.4	4.0	1.8	4.7	1.9	1.4	5.5	2.6	0.7	0.8	0.9	6.4	2.3	0.6	1.4	4.2	1.6	0.7	0.9	1.6
Ephedra nevadensis Brigham tea					22.5	9.0	7.3	28.2													1.6
Total Browse	493.4	76.9	193.6	85.9	250.5	100.0	25.9	99.9	253.2	66.0	50.3	59.3	169.6	60.9	20.7	45.8	118.4	45.5	27.7	34.8	68.9
GRASS																					
Aristida longiseta Three awn grass									4.6	1.2	1.5	1.8									0.3
Bouteloua gracilis Blue grama													24.8	8.9	6.4	14.2	57.6	22.1	29.3	36.8	7.9
Hilaria jamesii Curly grass	19.5	3.0	6.8	3.0					25.6	6.7	2.7	3.2	14.2	5.1	- 2.2	- 4.9	21.2	8.1	6.6	8.3	3.0
Oryzopsis hymenoides Indian rice grass									27.6	7.2	17.3	15.3	37.8	13.6	10.4	22.9	31.1	12.0	6.9	8.7	7.5
Stipa comata Needle and Thread													18.6	6.7	6.6	14.6					1.4
Sporobolus cryptandrus Sand dropseed	129.1	20.1	24.9	11.1					72.5	18.9	13.0	20.4	13.1	4.7	3.4	7.4	31.8	12.2	9.1	11.4	10.9
Total Grass	148.6	23.1	31.7	14.1					130.3	34.0	34.5	40.7	108.5	39.0	24.6	54.2	141.7	54.4	51.9	65.2	31.0
Grand Total	642.0	100.0	225.3	100.0	250.5	100.0	25.9	99.9	383.5	100.0	84.8	100.0	278.1	99.9	45.3	100.0	260.1	99.9	79.6	100.0	100.0

[1] Forage production refers only to forage available at the time of grazing by the experimental herd.

on the areas grazed during each of periods 1 and 2. Snow caused grass to become unavailable for grazing in period 2, and therefore it was eliminated from the diet.

A decline in the relative production of browse to grass in period 3, was accompanied by a corresponding decline in the preference shown for browse and in its importance in the diet. However, this class of forage still made up a slightly larger percentage of the diet than grass (59.3 percent).

Although browse produced a slightly larger percentage of the total available forage in period 4 than did grass, the wider choice of grass species and the decreased preference for browse reversed the amount of the two classes in the diet, with grass becoming the more important of the two.

Grass composed the larger part of the diet in period 5, and also produced the larger percentage of the total available forage on the area.

Although the two forage classes changed in their relative importance in the diet in the various periods, browse was the more important for the entire season (68.9 percent).

Composition of the Diet by Forage Species

Shadscale (Atriplex confertifolia) was the most abundant species on the study area and produced the largest quantity of available forage of any single species in all periods. The largest amount of forage produced by this species, 399.2 pounds per acre, was on the area grazed during period 1 and it was during this period that it appeared from diet composition to be more preferred than at any other time during the season. Both production and palatability at this time was due to the large plump fruit that remained on the current year's growth from

the previous growing season. Production decreased and was accompanied by a decline in the preference of this plant in following periods. However, even in the last period, this species produced more forage than any other species and for this reason it remained a significant part of the diet (seasonal average 59.0 percent) throughout the time of the study.

Although black sage (Artemisia nova) is regarded as a palatable and nutritious species, its relative infrequency on the study area prevented it from becoming important in the diet. Where this species occurred it became more significant in the diet, 3.8 percent, than amount of forage produced (0.9 percent of the total available production) might indicate.

Yellow brush (Chrysothamnus stenophyllus) occurred on all the areas grazed but varied from area to area in amount. The largest amount of available forage produced by this species was in the first period. Production in periods 2 and 3 declined while production in periods 4 and 5 showed an increase over periods 2 and 3. The amount of this species in the diet followed closely the amount available in the various periods.

White sage (Eurotia lanata) produces a large amount of forage on many sections of the winter range; but either because of past over-use on this allotment or unfavorable growing conditions, this species did not produce more than 6.4 percent of the total available forage on any area grazed by the experimental herd. Areas grazed in periods 3 and 5 were entirely lacking in this species and it did not become important in the diet in any period except period 2. Due to weather conditions in this period a larger amount of time was spent grazing

in a section that contained more white sage than the average for the area and thus a larger amount (25.3 percent) was included in the diet in this period than at any time during the season.

Snakeweed (Gutierrezia sarothrae) produced some forage in all periods, but this amount did not exceed 3 percent of the total herbage available in any period. The diet contained a small amount of this species in all periods, but this amount did not exceed 5.5 percent of the diet at any time.

Brigham tea (Ephedra nevadensis) was not particularly abundant on the study area except along dry gravelly washes, and some of the southern exposed slopes. This plant occurred most frequently in period 2 and, being a tall growing species, produced 8.97 percent of the total available forage, and made up 28.2 percent of the diet in this period.

Blue grama (Bouteloua gracilis), a low growing sod-forming grass, was unavailable to grazing in the early part of the season because of snow, but in the relatively snow-free periods, 4 and 5, it produced 8.91 and 22.14 percent of the total forage. Protection from grazing in the earlier winter had increased the relative production in the last two periods and caused it to become an important part of the diet (14.2 and 36.8 percent) in these periods.

Sand dropseed (Sporobolus cryptandrus) produced forage available for grazing in all periods except one (period 2). In periods 1 and 3 this species was second to shadscale in percent of total available forage produced. It was third in importance in the diet during period 1, and second in importance in period 3.

Curly grass (Hilaria jamesii), similar in growth form to blue grama but slightly taller growing, produced less than 10 percent of

the total available forage in any one period and appeared in the diet in about the same proportion. Forage produced by this species was coarse and not particularly palatable to sheep.

Indian rice grass (Oryzopsis hymenoides) is one of the more desirable grass species on the winter range. However, it was not uniformly distributed over the study area and made up less than 15 percent of the total available herbage even where most abundant. The sheep's diet in periods 3, 4, and 5 contained 15.3, 22.9 and 8.7 percent of this species.

Three-awn grass (Aristida longiseta) and needle-and-thread grass (Stipa comata) were each available for grazing in one period only. Three-awn grass produced a coarse wiry type of forage that was not particularly palatable to the sheep. As a result of the low palatability and the small amount of available forage produced, this species was less than 2 percent of the diet in period 4. The early-growth habit of needle-and-thread grass made this species particularly palatable to the sheep in period 4. Although producing only 6.7 percent of the total herbage available for grazing at this time, the diet contained 14.6 percent of this species.

Statistical Analysis of Plant Data

The average available forage production and the amount of herbage consumed for an average 100-square-foot plot on each section of the allotment grazed within each period was statistically analyzed to determine the accuracy of the values obtained.

Data from table 2 show the average amount of forage produced before and after grazing, and the amount of each species consumed for an average 100-square-foot plot within period 1. Column 2 of the table

Table 2. Average forage production before and after grazing, and the amount of each species consumed for an average 100-square-foot plot in period 1

Species	Avg. forage per 100 sq. ft.	Fiducial limits P.05 d.f = 4	C. V. *
BEFORE GRAZING			
Atriplex confertifolia	435.7 grams	±316.2 grams	58.5 percent
Chrysothamnus stenophyllus	74.2	150.1	163.0
Eurotia lanata	12.7	35.2	223.6
Gutierrezia sarothrae	16.6	45.9	223.6
Hilaria jamesii	21.1	36.0	136.9
Sporobolus cryptandrus	139.0	158.1	91.6
AFTER GRAZING			
Atriplex confertifolia	272.1	203.6	60.3
Chrysothamnus stenophyllus	34.0	66.0	156.5
Eurotia lanata	9.3	25.9	223.5
Gutierrezia sarothrae	12.2	33.9	223.6
Hilaria jamesii	13.8	23.4	137.0
Sporobolus cryptandrus	111.9	125.7	90.5
AMOUNT CONSUMED			
Atriplex confertifolia	163.6	141.9	69.9
Chrysothamnus stenophyllus	40.2	84.3	169.0
Eurotia lanata	3.4	9.4	194.0
Gutierrezia sarothrae	4.4	12.1	223.4
Hilaria jamesii	7.4	12.2	137.0
Sporobolus cryptandrus	27.1	39.3	116.8

* The standard deviation expressed as a percentage of the mean (average).

gives the fiducial limits or accuracy of predicting these values for each species. This means that at odds of 19:1 the true average value will lie somewhere between a value less than the sample average by the amount given in column 2 and another value larger than the sample average by the same amount.

The accuracy of determining forage production and consumption by species was found to be of the same magnitude in all periods, and for this reason only the results obtained in period 1 have been presented.

The data from table 2 indicate that 5 sampling units or transects do not determine accurately the amount of available forage produced or amount of individual species consumed over an area as large as that grazed in a single period (approximately 1 square mile). The fiducial limit values are larger than the average values for all species except shadscale (Atriplex confertifolia) and indicate a lack of uniformity of distribution of individual species over the area grazed during each period.

Data from table 3 show that considerable more accuracy was obtained in determining total forage production and consumption, without regard to individual species, than was obtained when it was attempted to break data down to species. Although species production was not uniformly distributed over the area, where one species did not occur another usually replaced it, which had the affect of making total forage production much less variable between transects than species production. The fiducial limit values in this case do not include zero as they did when measuring individual species production and, thus, fewer sampling units or transects would be required to measure the average total forage production than average forage production by individual species.

Table 3. Average forage production before and after grazing, and the amount consumed of all species combined for an agerage 100-square-foot plot in each period.

Period	d.f.	BEFORE GRAZING			AFTER GRAZING			AMOUNT CONSUMED		
		Avg. Forage prod. per 100 sq. ft.	Fiducial limits $P_{.05}$	C. V.*	Avg. Forage prod. per 100 sq. ft.	Fiducial limits $P_{.05}$	C.V.*	Avg. Amount consumed per 100 sq. ft.	Fiducial limits $P_{.05}$	C. V.
		(grams)		percent	(grams)		percent	(grams)		percent
1	4	699.3	±267.7	30.8	453.3	±249.1	44.3	246.0	± 74.1	24.3
2	5	271.6	144.9	50.8	243.4	142.5	55.8	28.3	29.3	105.8
3	3	416.6	335.4	50.6	328.0	258.2	49.5	88.6	111.6	79.2
4	5	305.9	141.2	56.9	256.4	148.6	55.2	49.5	12.9	25.0
5	5	286.5	135.5	45.0	199.2	74.9	35.8	87.3	66.0	70.1

* The standard deviation expressed as a percentage of the mean.

DAILY FORAGE CONSUMPTION

On ranges that produce forage of low quality, the amount of feed consumed daily often determines whether or not a nutritional deficiency occurs in the diet of the grazing animal.

The lack of a method to determine the daily amounts of forage consumed by sheep and the factors that effect this consumption, under natural conditions, has retarded nutritional studies on those ranges that produce forage of marginal quality. This is particularly true of many winter ranges in Utah.

It is common knowledge that sheep do not consume a constant quantity of forage from day to day. The nutritive content of the forage, climatic conditions, management practices, character of the forage, length of the grazing day, and the amount of forage produced per acre may all influence the daily forage consumption. One of the purposes of this study was to evaluate the factors which influence this consumption on winter ranges.

Forage Consumption by Collection Lambs

The lambs, from which feces collections were taken and the daily forage consumption determined by the lignin ratio method, provided the only means of evaluating the factors which effect forage consumption through the grazing season.

From these data, table 4, the least amount of forage consumed per day was at the beginning of winter grazing season (period 1). There were approximately 9 hours in each day that the sheep could have spent on the range. However, 3 or 4 hours were lost to the sheep every second day during this period, because of the time involved in handling the sheep for supplemental feeding. An additional loss in the actual time

Table 4. The average amount of forage consumed daily in each period by collection lambs ranging in weight from 75 to 90 pounds as compared to the amount of time available for grazing and the amount of forage produced per acre.

Period	Date	Average* time available for grazing per day	Oven D. M. produced per acre	Oven D.M. consumed daily per head
		hours	pounds	pounds
1	Nov. 26 to Dec. 18	7-7.5	641.9	2.04
2	Dec. 18 to Jan. 13	8-8.5	250.5	3.21
3	Jan. 13 to Feb. 3	9-9.5	383.5	3.04
4	Feb. 3 to March 10	9.5-10	278.1	3.71
5	March 10 to April 4	11	260.2	2.99

* Time sheep were out of the corrals and on the range.

spent grazing occurred because the sheep were apparently unaccustomed to grazing in a small herd. As a result considerable time was spent gazing around and moving about without actually grazing.

As the sheep became more accustomed to being handled, the amount of time spent out of the corrals and on the range increased. This increase in the available grazing time each day, and the colder weather occurring during period 2 increased the average forage consumption by 1.17 pounds. Colder weather had the effect of increasing the amount of time actually spent grazing by reducing the time spent idling about on the range. The sheep had also overcome much of their aversion to being in the small band at this time.

The slight decrease in the amount of forage consumed in period 3 probably resulted from the decreased palatability of browse due to the shattering of the fruit and leaves, and the warmer weather occurring in this period.

Ten days of cold weather at the end of period 4, the increased length of time spent grazing, and the presence of more palatable grass species (needle-and-thread grass, and Indian rice grass) increased the amount of forage consumed in period 4.

The marked reduction in forage consumption during period 5 resulted largely from the appearance of annual June grass (Bromus tectorum L.). Although growth was less than an inch in height and forage production by this species was very small, the sheep spent a large amount of time traveling in search of the green growth produced by this species and as a result lost considerable grazing time.

From these data it appears that the amount of forage produced per acre had the least effect on the average daily consumption by the

collection lambs. More important was the time actually spent grazing which was directly influenced by the time the sheep were out on the range and indirectly influenced by climatic conditions and the character of the forage.

Forage Consumption by Age Classes

The forage consumed by the collection lambs, as determined by the lignin ratio method, was used as the basis of calculating the amount consumed by an average sheep in each age class. For this calculation it was assumed that sheep consume forage in direct proportion to the 0.73 power of their body weight.

Data from table 5 show the average daily forage consumption of each age class in the five periods, as compared to the recommended allowances of the National Research Council (25). On this basis the amount of forage consumed daily is well above the recommended allowances in 4 of the 5 periods, with the exception of lambs in periods 1 and 3.

Lamb wethers were used for collections in all periods during the study and were the only animals available for this purpose in the first 3 periods. Two yearling wethers were obtained for collection purposes in periods 4 and 5 and the data obtained from these animals were used to supplement the data obtained from the lambs.

The average forage consumption of each age class in periods 4 and 5 was calculated using the lamb wethers as a basis and also the yearling wethers as the basis. A comparison of the values obtained is shown in table 6. These data indicate that the stage of maturity of the animals should not be ignored, as was done in table 5, when computing the forage consumption of different weight animals by the 0.73 power

Table 5. The calculated average forage consumed daily by an average sheep in each age class by periods of the grazing season as compared to the recommended allowances of the National Research Council.

Sheep age class	Weight range: Present data	Weight range: National Research Council	Average forage consumed daily*: Period 1	2	3	4	5	Recommended ** Allowances of National Research Council
	pounds	pounds	pounds					pounds
Lambs	76 to 82	70 to 90	2.05	3.20	2.77	3.61	2.89	2.79
Yearlings	114 to 119	110 to 130	2.76	4.34	3.69	4.74	3.83	3.28
3 yr.	134 to 141	130 to 140	3.22	4.88	4.15	5.28	4.24	3.46
4 yr.	134 to 140	130 to 140	3.16	4.92	4.16	5.27	4.23	3.46
5 to 6 yr.	130 to 135	130	3.12	4.80	4.08	5.17	4.13	3.42
Over 6 yr.	126 to 132	120 to 130	3.07	4.70	3.99	5.03	4.05	3.38

* Oven dry matter
**Calculated on basis of 90% oven dry matter

Table 6. Comparison of the calculated forage consumption of an average sheep in each age class when using collection lambs as the basis and when using collection yearlings as the basis in periods 4 and 5

Sheep age class	Range in weight	Average feed consumed daily Basis- lambs Period		Average feed consumed daily Basis- yearlings Period	
		4	5	4	5
	pounds	pounds		pounds	
Collection lambs	83 to 85	3.71*	2.99*	2.72	2.21
Collection yearlings	114 to 120	4.62	3.76	3.39*	2.78*
Lambs	80 to 82	3.61	2.89	2.65	2.14
Yearlings	117 to 119	4.74	3.83	3.47	2.83
3 yr.	134 to 138	5.28	4.24	3.88	3.13
4 yr.	134 to 138	5.27	4.23	3.86	3.12
5 to 6 yr.	130 to 134	5.17	4.13	3.79	3.05
Over 6 yr.	126 to 129	5.03	4.05	3.69	2.99

* Determined by the lignin ratio method.

function theory of Brody (4). Comparing the actual amount consumed by the wether lambs and yearlings in the two periods shows that if lambs are used as the basis, calculated forage consumption of older heavier animals is too high; and conversely, the use of yearlings for the calculation of the forage consumed by younger animals results in figures that are too low.

The energy requirements of growing sheep (as in other animals) are greater than those of adult sheep and, thus, their feed requirement per unit of body weight, per unit of surface area, or per unit of the 0.73 power function of body weight is proportionately greater than in adult sheep.

The lamb year of a sheep is, on the whole, a constant series of transitions in nutritional and physiological adjustments. Growth curves based on dimensional measurements and weights of sheep indicate that about 80 percent of the total growth of the animals is made during the first or lamb year and that full structural maturity is probably attained near the end of the second year (27). The yearling period is, thus, still a transitional phase in the life of the sheep and their feed requirements vary accordingly.

In computing the feed consumed by mature animals from the known consumption of yearlings, it appears that a correction for growth and possibly for sex must be considered.

Ritzman (28) in standard metabolism tests with groups of ram and ewe yearlings found no difference between the sexes when measured under the same seasonal and nutritive conditions. The castration of a young ram, however, lowered the basal metabolism of the animal by 12 percent of that existing before castration. From his investigations it would

appear that the use of unsexed yearlings may compensate for the added requirements of growth for yearlings in calculating the feed consumption of mature animals in the present study.

The values calculated for the various age classes in periods 4 and 5 when using yearlings as the basis were approximately 73.5 percent of the same values when lambs were used as the basis.

To put the forage consumption of each age class in all periods on the basis of the yearling values calculated in periods 4 and 5, the forage consumption of all age classes, except the lambs, in periods 1, 2, and 3 were reduced to 73.5 percent of the values given in table 5 for these periods. Table 7, shows these corrected values for periods 1, 2, and 3 and the values obtained by using the yearling wethers for periods 4 and 5, as compared to the recommended allowances of the National Research Council. Data from this table show that in comparison to the recommended allowances of the National Research Council, forage consumption in periods 1, 3, and 5 were below the recommended allowances, above in period 4, and of about the same magnitude in period 2.

The yearling wethers used in this study were purchased in Cedar City, Utah, and were being fed alfalfa hay at the time of purchase. The effect of moving the animals from this type of forage to lower quality range forage is not known. However, the date from table 6 indicate that the appetite of these sheep was depressed considerably by this change. Although these animals weighed 20 to 25 pounds more than the lambs used for collection purposes, the food intake in periods 4 and 5 was less by 0.32 and 0.21 pounds daily. This indicates that the average daily forage consumed by the various age classes is

Table 7. Corrected[1] forage consumption of an average sheep in each age class for periods 1, 2, and 3 as compared to the recommended allowances of the National Research Council

Sheep age class	Weight range	Average forage consumed daily					Recommended allowance of National Research Council
		Period					
		1	2	3	4	5	
	pounds	pounds					pounds
Lambs	76 to 82	2.05	3.20	2.77	3.61	2.89	2.79
Yearlings	114 to 119	2.03	3.19	2.71	3.47	2.83	3.28
3 yr.	134 to 141	2.37	3.59	3.05	3.88	3.13	3.46
4 yr.	134 to 140	2.32	3.62	3.06	3.86	3.12	3.46
5 to 6 yr.	130 to 135	2.29	3.53	3.00	3.79	3.05	3.42
Over 6 yr.	126 to 132	2.26	3.45	2.93	3.69	2.99	3.38

1. The original values as calculated using lambs as the basis were reduced to 73.5 percent of these values. The forage consumption of all periods is then comparable to the values determined in periods 4 and 5 when using yearling wethers as the basis.

probably slightly greater than is shown in table 7.

Errors Involved in Determining Forage Consumption

The method of determining forage consumption (lignin ratio method) used in this study, although used before in pasture investigations, is a new approach to range nutrition problems.

The primary purpose of collecting feces in this study was to test the feasibility of making such collections on animals grazing open range land, and develop techniques for handling the animals for this purpose.

It was realized that too few animals and age classes were involved for a statistically sound interpretation of the data obtained. However, the data from table 8 indicate that the average daily oven dry matter excreted by lambs within a period of 3 to 4 weeks, can be determined with considerable accuracy. The accuracy obtained with 4 degrees of freedom (period 5) indicates that only a small number, probably 4 to 10, of animals would be required for such determinations. The older age groups were found to be more variable in body weight than the lambs in the experimental herd and would likely require more animals for feces collection purposes than would be required in the lamb age class. Even so, a large number in each age class would probably not be required for accurate determinations.

The variation in the amount consumed by collection lambs, as determined by the lignin ratio method, results from two sources. First, the variation in the amount of oven dry matter excreted, and second, the varying lignin content of the feces excreted by each animal. The lignin content of the feces in this study varied only between 19.26 and 21.92 percent over the entire season and all collection

Table 8: The average daily dry matter excreted and the average daily dry matter consumed by collection lambs in each grazing period.

	Average for period	Fiducial limits P.05	C. V. *
PERIOD 1 d.f. = 1			
Weight of collection lambs	75.2 pounds	± 54.0	7.99 percent
Daily oven D.M. excreted	1.18	0.32	3.05
Daily oven D.M. consumed	2.04	0.31	5.37
PERIOD 2 d.f. = 1			
Weight of collection lambs	77.8	34.93	5.00
Daily oven D.M. excreted	1.89	0.82	4.88
Daily oven D.M. consumed	3.21	1.65	5.73
PERIOD 3 d.f. = 3			
Weight of collection lambs	89.9	4.0	2.78
Daily oven D.M. excreted	1.40	0.09	2.37
Daily oven D.M. consumed	3.04	0.15	3.20
PERIOD 4 d.f. = 2			
Weight of collection lambs	85.2	7.6	3.59
Daily oven D.M. excreted	1.32	0.06	1.86
Daily oven D.M. consumed	3.71	0.57	6.18
PERIOD 5 d.f. = 4			
Weight of collection lambs	83.5	4.1	3.98
Daily oven D.M. excreted	1.47	0.15	8.16
Daily oven D.M. consumed	2.99	0.33	8.94

* Standard deviation expressed as a percentage of the mean.

animals. With such small variation as occurred, the accuracy of determining forage consumption was high even though only a small number of animals was used.

The largest source of error in determining forage consumption lies in determining the lignin content of the ingested forage. A fact that is frequently overlooked by pasture investigators is that the lignin content of the forage before grazing may be quite different from the lignin content of that part of the forage ingested. The lignin content of the forage ingested in this study, as determined from the differences of the before and after grazing samples, was as much as 43 percent less than the lignin content of the forage before grazing. Using values obtained from the analysis of the forage before grazing for the calculation of forage consumption by the lignin ratio method will result in values that are too low, and thus misleading.

CONCLUSIONS

There is a need for additional information concerning the diet of sheep and the amount of forage consumed daily by sheep when grazing desert winter ranges. The low productivity of these ranges and the generally low quality of forage produced make this information necessary for proper management of the range and range livestock.

The before and after method of sampling provided an accurate estimate of the available forage production only along the transect on which samples were taken. The data obtained by Green (21) when using a similar sampling procedure as was used in this study, show that the differences between duplicate samples of each species taken on individual transects were not significantly different when 200 to 500 units of browse species or 20 to 30 units of bunch grasses were collected

in each sample. It is reasonable to conclude that when the population is defined as the production on a transect, intensive sampling of the transect, as was done in this study as well as in the study made by Green, will result in accurate estimates of the parameter values for the transect. However, when the transect is considered as a sampling unit and is used to estimate the production parameters of a larger area, as was done in both studies, the variation between transects must be considered in determining the accuracy of the results obtained. This variation between transects was completely overlooked by Green in his study of the forage production and diet of sheep on the winter range.

It is concluded from this study that less time should be spent in sampling a single transect so that a larger number of transects could be sampled in each grazing period. The increased number of degrees of freedom for estimating the average variation between transects would more than offset the disadvantage of determining the values on the transect with less accuracy.

Serious consideration should be given to an optimum size for the transect or sampling unit to yield a maximum of information with a minimum amount of time in sampling. A full day often was required to sample a single transect of the size used in this study, and this greatly reduced the number that could be sampled on an area before the sheep arrived.

Another consideration is the possibility of subdividing the area to be grazed into units that are uniform in vegetation type. Fewer transects would be required to sample each unit with accuracy than would be required with a larger number that crossed type boundaries and were thus more variable between transects.

Although the results obtained in this study concerning the available forage production before and after grazing, and the amount of forage consumed in each period have been shown to be statistically unreliable, general observations during the study substantiate somewhat the results obtained.

The amount of each forage class and plant species in the diet of the sheep during the various periods was apparently, to a large extent, controlled by the relative amount of available forage produced by each class of forage and by each species. Of less importance was the preference that the sheep may have had for a particular species. Some observations made at the time sheep were grazing showed that, in general, the animals grazed the plant directly in front of them, taking a mouthful or two, and then moved on to the next closest plant. The species that were the most abundant consequently composed the larger amount in the diet.

Of interest was the manner in which shadscale was grazed. The sheep did not, in general, bite off a portion of the woody stem, but instead licked the leaves and fruit from the woody growth. Grazing in this fashion tends to make the diet much more nutritious than a chemical analysis of the entire current year's growth might indicate.

The lignin ratio method of determining the average daily forage consumption of sheep on winter ranges appears, from this study, to have considerable promise as a means of solving range nutrition problems concerning the adequacy of the range forage in meeting the requirements of sheep.

The small variation between animals in average oven-dry matter excreted and the small variation in lignin content of this excreta

(between 19.26 and 21.92 percent over the entire season and all collection animals used) suggests that for such determinations only a small number of young animals would be needed. A slightly larger number would likely be needed in the older age classes, however, this number probably would not be excessive.

The greatest limitation to the application of this method is in determining accurately the lignin content of the forage consumed. With adequate sampling, the before and after method seems to provide the most accurate procedure available at this time.

A fact sometimes overlooked by pasture investigators in applying the lignin ratio method is that the lignin content of the plant parts actually consumed may be quite different from the lignin content of the parts of the plant which ordinarily are collected for chemical analysis. The results of this study show that, by differences of the before and after grazing samples, the lignin content of the ingested forage was as much as 43 percent less than the lignin content of the forage before grazing. The lignin content of the forage as determined by the usual collection procedure, would give figures that are below the acutal forage consumption and thus mislead the investigator in evaluating the nutritive level of the diet.

The lignin ratio method also provides a means of calculating the digestibility of the nutrients in the diet if the nutrient content of the forage and the feces is known. The procedure used in this study will supply all of this information, however, complete data are not presented here.

The forage consumption of wether lambs, in this study shows that forage consumption was greater in periods 2, 4, and 5, about the same

in period 3, and less in period 1 than the recommended allowances of the National Research Council. Although the total dry-matter consumption was generally equal to or greater than the recommended allowances, the quality of the winter range forage is in all probability below the quality of the forage upon which these allowances are based. However, the lambs gained weight normally through the season which suggests that either the extra forage consumed offset the lower quality of the range forage or that the quality of the forage consumed may not be as low as suspected. This substantiates the opinion of some range investigators.

SUMMARY

1. A study to determine the diet and forage consumption of sheep on Utah's winter range, initiated in 1946-47, was continued during the winter of 1947-48. Data for the study were obtained in Pine Valley, 40 miles northwest of Milford, Utah.

2. For the purposes of the study a random sample of 160 sheep from a typical winter band of grade Rambouillet ewes was taken to form the experimental herd.

3. The grazing season was subdivided into grazing periods of approximately 3 weeks in length. The vegetation on the areas grazed in each period was sampled by the "before and after" method to determine the average available forage production before and after grazing and the amount of forage consumed per acre in each grazing period.

4. The average daily forage consumption of lambs was determined by the lignin ratio method and, using the theory that animals consume forage in a quantity proportionate to the 0.73 power of their body weight, the forage consumption of an average-weight sheep in each age

class was calculated.

5. The amount of browse and grass in the diet of the sheep during the study correlated closely with the amount of available forage produced by each class. Browse was the more important in the diet in the first 3 grazing periods and grass in the latter 2. Browse produced more forage available for grazing in the first 4 periods than did grass, but was second to grass in the last period.

6. The percentage composition of the diet by forage species also was correlated closely with the relative amounts of available forage produced by each species. Weather influenced the available forage production of grass species more than browse species. Because of snow that covered the area grazed in period 2, grass species were unavailable for grazing in this period and were therefore eliminated from the diet. The protection of grass species from grazing in the earlier part of the season increased the relative amount of available forage produced by these species in the latter part of the season.

7. Statistical analysis of the plant sampling data show that too few transects were used to determine accurately the average available forage production of the range before and after grazing or to measure accurately the amount consumed over an area as large as that grazed in a single period.

8. The factors which affect forage consumption, as determined by the lignin ratio method, are the length of the grazing day, climatic conditions, and the character of the forage. A short grazing day reduced forage consumption, cold weather increased forage consumption, and the appearance of new green growth in the form of annual June grass decreased forage consumption.

9. The forage consumption of lambs as determined by the lignin ratio method was above the recommended allowances of the National Research Council in periods 2, 4, and 5; below in period 1, and of about the same magnitude in period 3.

10. The forage consumption of the various age classes, as calculated from before-and-after plant samples was below the recommended allowances of the National Research Council in periods 1, 3, and 5; above in period 4, and of about the same magnitude in period 2.

11. A statistical analysis of the average oven-dry matter excreted and the lignin content of this excreta shows that a large number of animals would not be needed to determine the average amount of feces and average lignin content of the feces for lambs.

12. It was concluded from this study that too few transects were used to sample the vegetation to determine accurately the average available forage production before and after grazing or the amount consumed on an area as large as that grazed in a single period. It was further concluded that the lignin-ratio method of determining forage consumption offers greater possibilities in range nutrition studies than any other method now in use.

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APPENDIX

INDEX TO THE SYMBOLS USED, AND THE COMMON AND SCIENTIFIC NAMES OF PLANTS

Symbol	Scientific Name	Common Name
Aco	*Atriplex confertifolia* (Torr.) Wats.	Shadscale
Ano	*Artemisia nova* A. Nels.	Black sage
Cat	*Chrysothamnus stenophyllus* (A. Gray) Greene	Yellow brush
Ela	*Eurotia lanata* (Pursh) Moq.	White sage
Enev	*Ephedra nevadensis* S. Wats.	Brigham tea
Gsa	*Gutierrezia sarothrae* (Pursh) B. & R.	Snakeweed
ARI	*Aristida longiseta* Steud.	Three-awn grass
Bgr	*Bouteloua gracilis* (H.B.K.) Lag.	Blue grama
Hja	*Hilaria jamesii* (Torr.) Benth	Curly grass
Ohy	*Oryzopsis hymenoides* (Roem. & Schult) Ricker	Indian rice grass
Sco	*Stipa comata* Trin. & Rupr.	Needle and Thread grass
Ser	*Sporobolus cryptandrus* (Torr.) Gray	Sand dropseed

APPENDIX

DESCRIPTION OF UNITS AND OBSERVATIONS

BROWSE

Atriplex confertifolia (Acc)

Unit----------The current years growth including the fruit, leaves, and woody portion. Each sample consisted of 1000-14000 units collected out and back along the transect.

Observation---The observation was designated as a major branch of the plant (See Figure 8) and contained 15-50 units. All units on an observation were placed in the sample bag as part of the sample. Observations were taken at 4-or 5-pace intervals along the transect.

Artemisia nova (Ano)

Unit----------The current year's growth, including the flower stalk, leaves, and woody portion. Two-thousand to three-thousand units comprised the sample.

Observation---An entire plant was designated as the observation and contained from 50 to 200 units. Observations were collected at 3-pace intervals along the transect. This plant occurred in sufficient abundance to collect only in period 3.

Chrysothamnus stenophyllus (Cst)

Unit----------The current year's growth, including the leaves and woody portion. Each sample contained 800 to 1600 units.

Observation---The observation was designated as a major branch of the plant and contained 10 to 40 units. Observations were collected at 3 to 4 pace intervals along the transect.

Eurotia lanata (Ela)

Unit----------A unit consisted of the current year's growth of an entire plant, which was separated from the older woody portion after clipping. Each sample contained 40 to 50 units.

Observation---The observation varied in the different periods from 1 to 3 plants at each 3 paces along the transect. (See Figure 9).

APPENDIX

Figure 8. Illustration of the winter range forage plant shadscale (Atriplex confertifolia), (A) showing an observation containing several units, (B) an ungrazed unit, and (C) a grazed unit.

APPENDIX

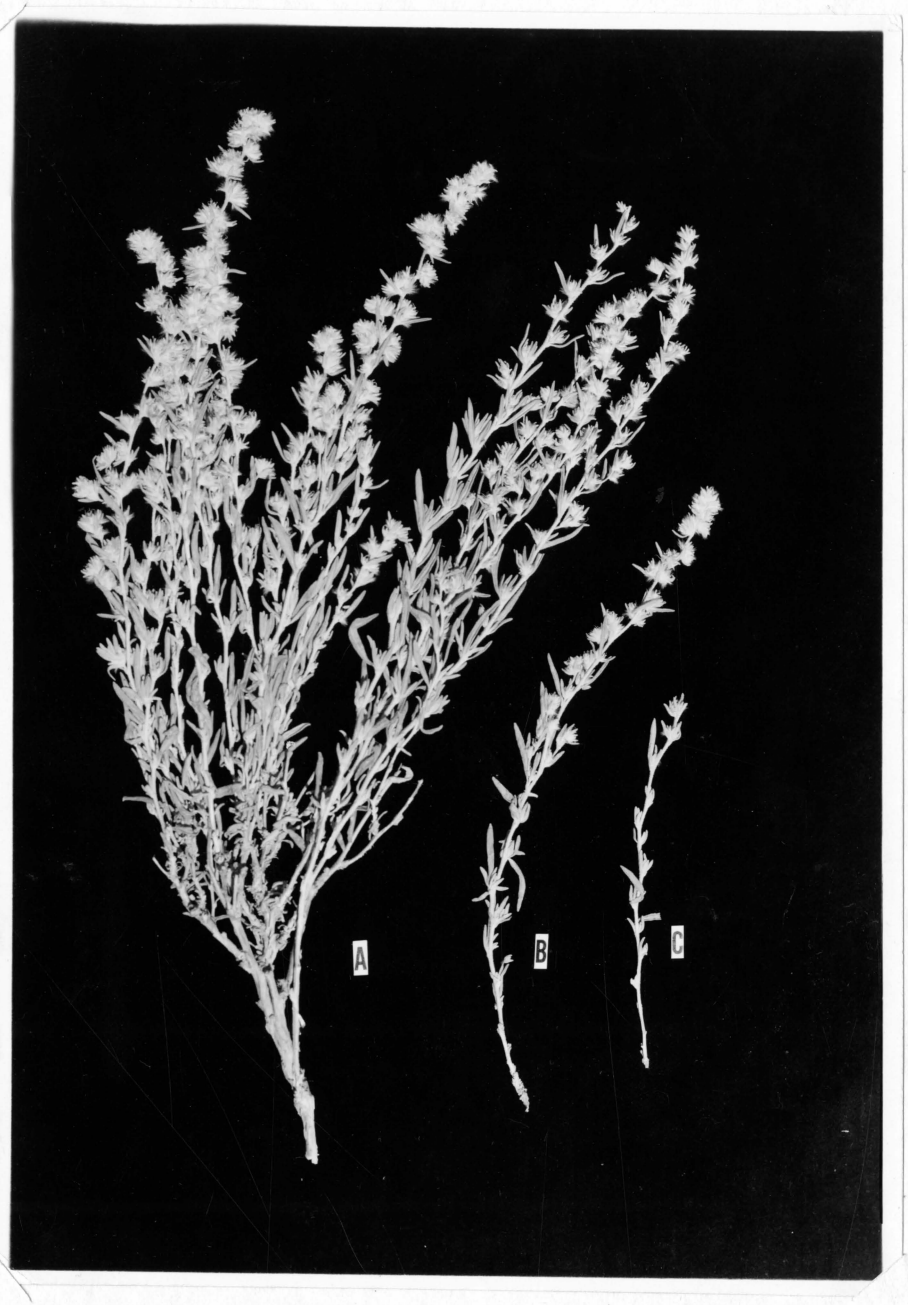

Figure 9. Illustration of the winter range forage plant white sage (Eurotia lanata), (A) the entire plant comprising a unit and also an observation, (B) a portion of the before grazing unit (current year's growth stripped from woody portion of the plant), and (C) a portion of the after grazing unit.

APPENDIX

DESCRIPTION OF UNITS AND OBSERVATIONS

FORBS

Ephedra nevadensis (Enev)

Unit----------A unit consisted of a branch of the current year's growth cut below a node at which 4 or more branclets emerged. The sample contained 160 to 200 units. This designation of units was not found to be satisfactory due to the great variability between units. The plant was collected only in period 3.

Observation---Five units collected at each 5 paces along the transect was designated as an observation.

Gutierrezia sarothrae (Gsa)

Unit----------The unit varied from a complete plant in period 2 to a grass shearer eye full in periods 3 and 4, and to individual stems of each plant in periods 5 and 6. The sample consisted of 30 to 70 units in periods 2 to 4, and 1300 to 2000 in periods 5 and 6.

Observation---The observation consisted of an entire plant collected at 3 to 4 pace intervals along the transect in all periods.

GRASS

Aristida longiseta (ARI)

Unit----------The entire plant cut at ground level. Each sample contained 80 to 110 units.

Observation---The observation varied from 2 to 3 units collected at 5 pace intervals along the transect.

Bouteloua gracilis (Bgr)

Unit----------A unit consisted of a compact section of the sod which could be called an entity in itself, and could be clearly distinguished from the surrounding sod.

Observation---The observation varied from 5 to 10 units at 5 pace intervals along the transect.

APPENDIX

DESCRIPTION OF UNITS AND OBSERVATIONS

GRASS

Hilaria jamesii (Hja)

Unit----------A unit consisted of from 1 to 10 culms arising from the same point and clearly separated from the surrounding plants. A sample consisted of 100 to 200 units.

Observation---The observation varied from 5 to 10 units collected at 5 pace intervals along the transect.

Oryzopsis hymenoides (Ohy)

Unit----------An individual plant cut at ground level. A sample contained 60 to 150 units.

Observation---One unit collected at 3 to 5 pace intervals along the transect.

Stipa comata (Sco)

Unit----------An individual plant cut at ground level. A sample contained 130 to 200 units.

Observation---One unit collected at 3 pace intervals along the transect.

Sporobolus cryptandrus (Scr)

Unit----------A individual plant cut at ground level. A sample contained 100 to 150 units.

Observation---One unit collected at 5 pace intervals along the transect.